U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-269 252

Tuttle Creek Reservoir Marshall, Pottawatomie and Riley Counties, Kansas

National Eutrophication Survey, Corvallis, Oreg

Prepared for

Corvallis Environmental Research Lab, Oreg

Apr 77

PB 269 252

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY
WORKING PAPER SERIES

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

U.S.P.S. 699-440

REPORT

ON

TUTTLE CREEK RESERVOIR

MARSHALL, POTTAWATOMIE, AND

RILEY COUNTIES

KANSAS

EPA REGION VII

WORKING PAPER NO. 524

WITH THE COOPERATION OF THE

KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT

AND THE

KANSAS NATIONAL GUARD

APRIL, 1977

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1 REPORT NO.	2
3 RECIPIENT'S ACCESSION NO.	
4 TITLE AND SUBTITLE: Report on Tuttle Creek Reservoir, Marshall, Pottawatomie, and Riley Counties, Kansas	5 REPORT DATE: Prepared April 1977
	6 PERFORMING ORGANIZATION CODE
7 AUTHOR(S): Anonymous (National Eutrophication Survey Staff)	8 PERFORMING ORGANIZATION REPORT NO: Working Paper # 524
9 PERFORMING ORGANIZATION NAME AND ADDRESS: National Eutrophication Survey, U.S. Environmental Protection Agency, 200 S. W. 35th St., Corvallis, Oregon 97330	10 PROGRAM ELEMENT NO.
	11 CONTRACT/GRANT NO.
12 SPONSORING AGENCY NAME AND ADDRESS: Office of Research and Development, U.S. Environmental Protection Agency, 401 M Street, S. W., Washington, DC 20460	13 TYPE OF REPORT AND PERIOD COVERED: Final - 1974
	14 SPONSORING AGENCY CODE

15 SUPPLEMENTARY NOTES: Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16 ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17 KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

18 DISTRIBUTION STATEMENT: Release unlimited	19 SECURITY CLASS (This Report)	21 NO. OF PAGES: 38
	20 SECURITY CLASS (This Page)	22 PRICE: PB 269 881

EPA Form 2220-1 (9-73)

CONTENTS

	Page
Foreword	ii
List of Kansas Study Reservoirs	iv
Lake and Drainage Area Map	v
Sections	
I. Conclusions	1
II. Lake and Drainage Basin Characteristics	4
III. Lake Water Quality Summary	5
IV. Nutrient Loadings	10
V. Literature Reviewed	16
VI. Appendices	17

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

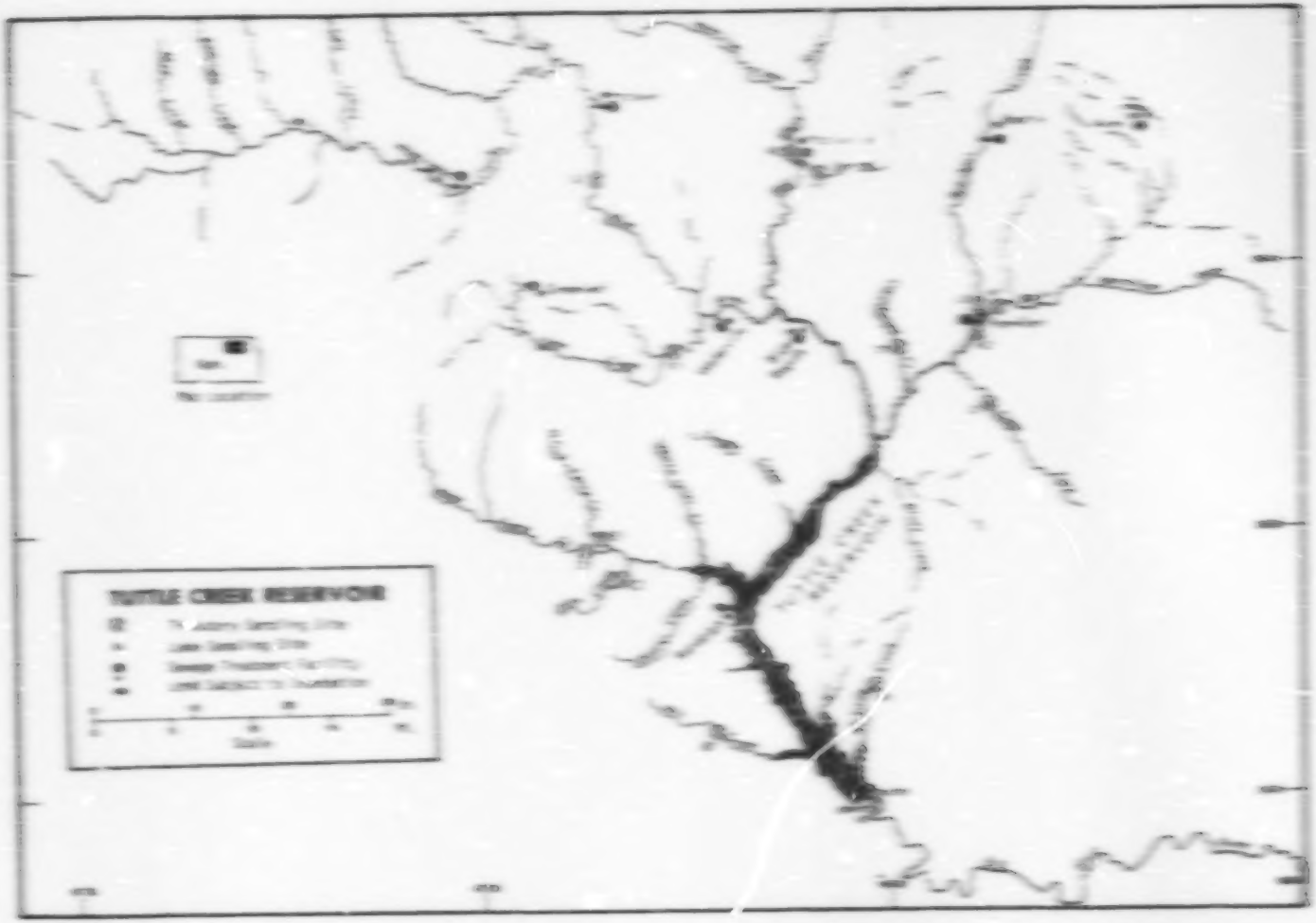
The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Kansas State Department of Health and Environment for professional involvement, to the Kansas National Guard for conducting the tributary sampling phase of the Survey, and to those Kansas wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

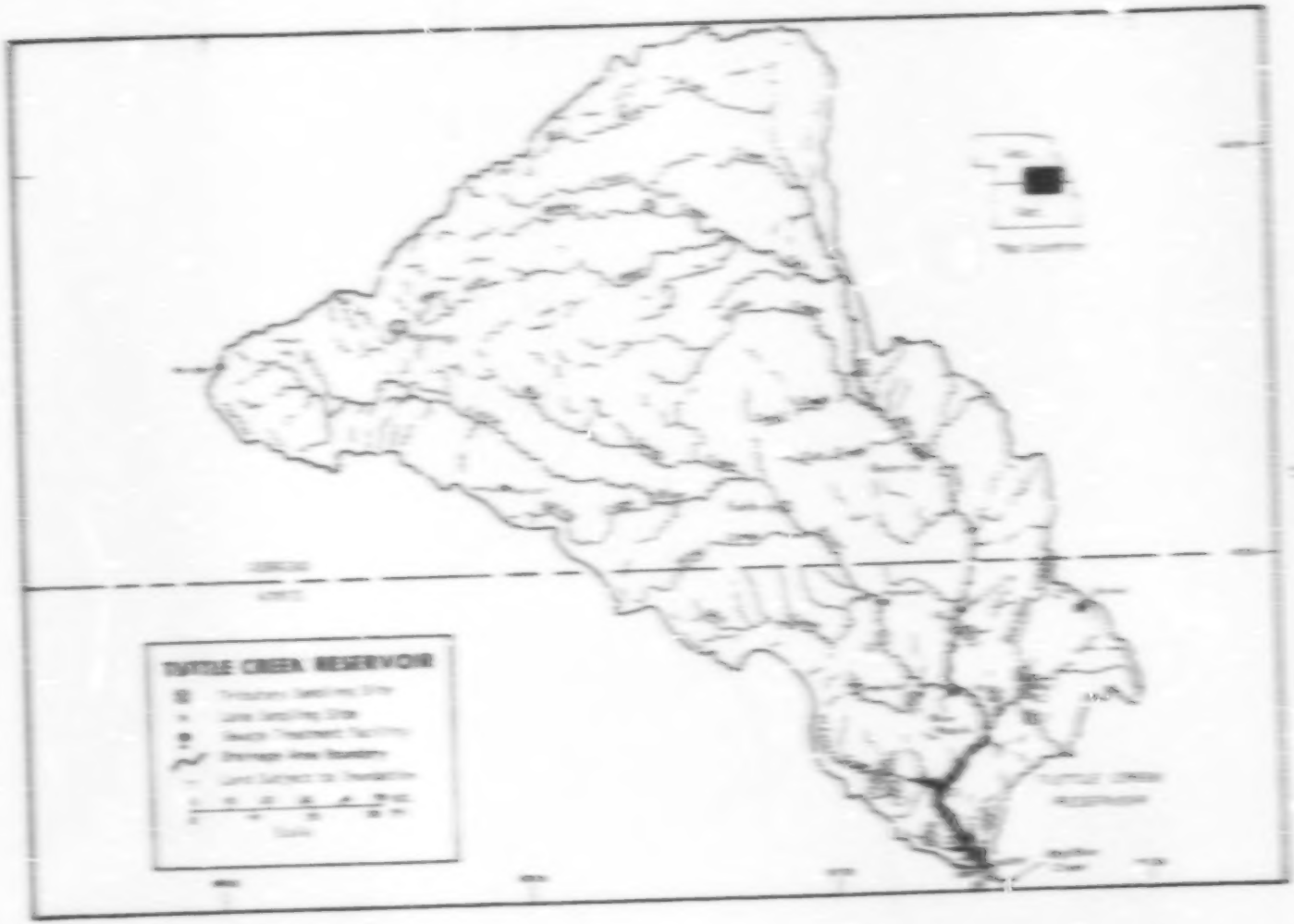
The staff of the Kansas Division of Environmental Health provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General Edward R. Fry, the Adjutant General of Kansas, and Project Officer Colonel Albin L. Lundquist, who directed the volunteer efforts of the Kansas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY
STUDY RESERVOIRS
STATE OF KANSAS

NAME	COUNTY
Cedar Bluff	Trego
Council Grove	Morris
Elk City	Montgomery
Fall River	Greenwood
John Redmond	Coffey, Lyon
Kanopolis	Ellsworth
Marion	Marion
Melvern	Osage
Milford	Clay, Geary
Norton	Norton
Perry	Jefferson
Pomona	Osage
Toronto	Greenwood, Woodson
Tuttle Creek	Marshall, Potta-watomie, Riley
Wilson	Russell


TURTLE CREEK RESERVOIR


TUTTLE CREEK RESERVOIR

TUTTLE CREEK RESERVOIR

STORET NO. 2014

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate Tuttle Creek Reservoir is potentially eutrophic. However, the reservoir becomes quite turbid during periods of runoff, and primary productivity is intermittently light-limited (Kring, 1977).

This water body ranked last in overall trophic quality among the 15 Kansas reservoirs sampled when compared using a combination of six water quality parameters*. All of the other reservoirs had less median total phosphorus and dissolved orthophosphorus, 11 had less and one had the same median inorganic nitrogen, nine had less mean chlorophyll a, and four had greater mean Secchi disc transparency. Marked depression of hypolimnetic dissolved oxygen occurred at sampling station 1 in June.

Survey limnologists did not observe concentrations of algae or macrophytes during sampling visits.

The low Secchi disc transparencies and numbers of phytoplankton indicate that at times primary productivity in the reservoir is light-limited as noted above. In several reports it is stated that Tuttle Creek Reservoir is eutrophic, has high nutrient levels, but has only low to moderate productivity due to lack of light penetration. This is generally attributed

* See Appendix A.

to the morphology of the basin and to winds which tend to maintain turbid conditions and also limit the time available for photosynthesis because of vertical mixing (Klassen and Marzolf, 1971; Marzolf and Osborne, 1972; Osborne and Marzolf, 1972).

B. Rate-Limiting Nutrient:

Due to significant nutrient changes in the samples during shipment, the results of the algal assays are not considered representative of conditions in the reservoir at the times the samples were taken. Nutrient-wise, the reservoir data indicate nitrogen limitation in April and phosphorus limitation at two of the three sampling stations in October.

C. Nutrient Controllability:

1. Point sources--During the sampling year, point sources contributed only 0.7% of the total phosphorus load to Tuttle Creek Reservoir. The wastewater treatment plants at Marysville and Blue Rapids contributed 0.3% and 0.2% of the total load, respectively. Eight other facilities collectively contributed 0.2%.

The present total phosphorus loading of 22.28 g/m^2/year is nearly 26 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 15). Removal of phosphorus at the point sources probably would not improve the trophic condition of the reservoir since primary productivity is light-limited part of the time.

It should be noted that if soil-conservation practices are initiated to reduce erosion in the watershed and resulting turbidity in the reservoir, the existing nutrient load is likely to cause a marked increase in primary productivity. However, it appears that a significant reduction of the phosphorus loading can only be accomplished by control of all sources impacting the Big Blue and Little Blue rivers (see discussion below).

2. Non-point sources--Non-point sources contributed 99.3% of the total phosphorus load during the sampling year. The Big Blue River contributed 60.5%, the Little Blue River contributed 33.9%, and seven other gauged tributaries collectively contributed 2.7%. The ungaged tributaries contributed an estimated 2.1% of the total load.

The phosphorus export rates of the Big Blue and Little Blue rivers (70 kg/km^2/year and 56 kg/km^2/year) were substantially higher than the rates of the other gaged tributaries in the drainage basin (see page 14). This may be due to other point sources beyond the 40-kilometer limit of the Survey* (e.g., Hastings and Fairbury, Nebraska) or to land-use practices in the drainage basin. In a recent report, it is noted that much of the drainage is cropland, pasture, and range (Anonymous, 1975).

* See Working Paper No. 175; "...Survey Methods, 1973-1976".

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 63.94 kilometers².
2. Mean depth: 8.25 meters.
3. Maximum depth: 20.0 meters.
4. Volume: 524.608 x 10^6 m^3.
5. Eleven-year median hydraulic retention time: 139 days.

B. Tributary and Outlet;
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Big Blue River	12,372.4	23.270
Otter Creek	57.0	0.100
West Fancy Creek	271.9	0.800
N. Fork Fancy Creek	93.0	0.280
Coon Creek	255.4	0.810
Little Blue River	8,609.2	16.580
Robidoux Creek	303.0	0.960
Black Vermillion River K-1	735.6	2.510
Clear Fork	115.5	0.370
Minor tributaries & immediate drainage -	2,090.7	6.980
Totals	24,903.7	54.748

2. Outlet -

Big Blue River	24,967.6**	52.860

C. Precipitation***:

1. Year of sampling: 75.4 centimeters.
2. Mean annual: 85.1 centimeters.

† Table of metric conversions--Appendix B.
†† Kring, 1977.
* For limits of accuracy, see Working Paper No. 175.
** Includes area of reservoir.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Tuttle Creek Reservoir was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at three stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first and last visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 18.3 meters at station 1, 10.7 meters at station 2, and 7.6 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table (the June nutrient samples were not properly preserved and were not analyzed).

[illegible] SUMMARY OF [illegible] AND CHEMICAL CHARACTERISTICS AT TURTLE CREEK RESERVOIR
STREET CODE 2B2

PARAMETER	[illegible] SAMPLING [illegible]			[illegible] SAMPLING [illegible]			[illegible] SAMPLING [illegible]		
	[illegible]			[illegible]			[illegible]		
TEMP (C)	4.2 - 11.4	8.8	8.4	23.4 - 25.4	24.5	25.7	15.1 - 17.4	16.4	16.2
DISS OXY (MG/L)	8.4 - 10.6	10.0	10.2	1.4 - 4.2	5.7	4.8	7.6 - 9.1	8.1	8.1
ALKALINITY (MG/L)	301. - 318.	412.	316.	321. - 418.	364.	333.	415. - 421.	418.	417.
PH (STAND UNITS)	8.1 - 8.3	8.2	8.1	8.8 - 9.0	8.3	8.4	8.0 - 8.2	8.1	8.1
TOT ALK (MG/L)	295. - 304.	217.	294.	----------	----------	----------	295. - 302.	295.	294.
TOT P (MG/L)	0.178 - 0.244	0.202	0.216	----------	----------	----------	0.202 - 0.242	0.227	0.221
DISS P (MG/L)	0.083 - 0.155	0.121	0.149	----------	----------	----------	0.056 - 0.067	0.060	0.062
NO2+NO3 (MG/L)	0.467 - 1.281	1.040	1.019	----------	----------	----------	0.708 - 0.843	0.809	0.806
AMMONIA (MG/L)	0.122 - 0.148	0.145	0.139	----------	----------	----------	0.038 - 0.078	0.054	0.045
TKN (MG/L)	1.330 - 1.481	1.445	1.421	----------	----------	----------	1.401 - 1.488	1.447	1.439
INORG N (MG/L)	0.778 - 1.040	1.085	1.040	----------	----------	----------	0.760 - 1.004	1.085	1.085
TOTAL N (MG/L)	1.330 - 1.481	1.425	1.439	----------	----------	----------	1.330 - 1.740	1.457	1.446
CHLOPHYL A (MG/L)	5.1 - 34.5	15.1	14.3	2.6 - 14.4	7.5	5.4	7.5 - 15.8	11.1	10.7
SECCHI (METERS)	0.4 - 0.7	0.6	0.6	0.3 - 0.3	0.3	0.4	0.2 - 0.4	0.3	0.2

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
06/11/74	1. Stephanodiscus sp.	10,047
	2. Chroomonas sp.	2,230
	3. Cryptomonas sp.	241
	4. Ankistrodesmus sp.	181
	5. Nitzschia sp.	60
	Other genera	62
	Total	13,729
06/25/74	1. Stephanodiscus sp.	1,703
	2. Chroomonas sp.	183
	3. Melosira sp.	61
	4. Cryptomonas sp.	29
	5. Euglena sp.	30
	Other genera	76
	Total	2,083
10/02/74	1. Nitzschia sp.	1,041
	2. Stephanodiscus sp.	1,462
	3. Flagellates	204
	4. Skeletonema sp.	189
	5. Chroomonas sp.	150
	Other genera	95
	Total	3,819

B. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
04/11/74	1	5.1
	2	6.3
	3	34.6
06/25/74	1	2.0
	2	14.4
	3	6.4
10/02/74	1	2.5
	2	9.2
	3	15.8

C. Limiting Nutrient Study:

The algal assay results are not considered representative of conditions in the reservoir at the times the samples were taken (04/11/74 and 10/02/74) due to significant changes in nitrogen and phosphorus during shipment from the field to the laboratory.

The reservoir data indicate a combination of limiting nutrients, although it will be noted that station 3 nearest the point sources tended toward nitrogen limitation while the two stations further away tended more toward phosphorus limitation.

Following is a tabulation of the mean inorganic nitrogen/orthophosphorus ratios for each of the sampling stations and

times with the indicated limiting nutrient in parentheses (however, note that primary productivity is intermittently light-limited; Kring, 1977).

Station	04/11/74	10/08/74
1	13/1 (N?)	17/1 (P)
2	13/1 (N?)	16/1 (P)
3	10/1 (N)	12/1 (N)

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Kansas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the maps (pages v and vi), except for the months of May, June, and July when two samples were collected at a number of the sites. Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Kansas District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in kg/km^2/year, at stations C-1, D-1, E-1, and L-1 and multiplying the means by the ZZ area in km^2.

The operators of the Beattie, Blue Rapids, Frankfort, Marysville, Randolph, and Watersville wastewater treatment plants provided monthly effluent samples and corresponding flow data. The operators of the

* See Working Paper No. 175.

wastewater treatment plants at Axtell, Greenleaf, Hanover, and Washington also provided monthly samples, but corresponding flow data were not available. Nutrient loads from these sources were estimated at 1.134 kg P and 3.401 kg N/capita/year, and flows were estimated at 0.3785 m^3/capita/day.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Axtell	514	tr. filter	194.6	Vermillion River
Beattie	296	stab. pond	106.0	Trib. of Robidoux Creek
Blue Rapids	1,298	prim. clarifier	649.2	Big Blue River
Frankfort	1,060	stab. pond	772.5	Black Vermillion River
Greenleaf	485	tr. filter	193.6	Coon Creek
Hanover	858	prim. clarifier	317.2	Little Blue River
Marysville	3,[illegible]0	prim. clarifier	1,[illegible]09.8	Big Blue River
Randolph	1[illegible]4	act. sludge	32.6	Peach Creek
Washington	1,700	tr. filter	643.5	Peach Creek
Waterville	750	prim. clarifier	298.9	Little Blue River

2. Industrial - Unknown

* Treatment plant questionnaires.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Big Blue River	861,300	60.5
Otter Creek	735	<0.1
West Fancy Creek	3,950	0.3
N. Fork Fancy Creek	1,410	0.1
Coon Creek	3,960	0.3
Little Blue River	482,715	33.9
Rubidoux Creek	8,695	0.7
Black Vermillion River E-1	16,785	1.2
Clear Fork	1,310	0.1
b. Minor tributaries & immediate drainage (non-point load) -	29,695	2.1
c. Known municipal STP's -		
Axtell	585	<0.1
Beattie	310	<0.1
Blue Rapids	2,555	0.2
Frankfort	1,050	<0.1
Greenleaf	550	<0.1
Hanover	730	0.1
Marysville	3,975	0.3
Randolph	100	<0.1
Washington	1,930	0.1
Waterville	865	<0.1
d. Septic tanks - Unknown	?	-
e. Industrial - Unknown	?	-
f. Direct precipitation* -	1,120	0.1
Total	1,424,305	100.0

2. Outputs -

Lake outlet - Big Blue River 229,125

3. Net annual P accumulation - 1,195,180 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Big Blue River	4,282,460	55.3
Otter Creek	10,355	0.1
West Fancy Creek	72,290	1.0
N. Fork Fancy Creek	25,170	0.3
Coon Creek	223,550	2.9
Little Blue River	2,159,065	28.0
Mobidoux Creek	121,720	1.6
Black Vermillion River K-1	212,200	2.8
Clear Fork	23,580	0.3
b. Minor tributaries & immediate drainage (non-point load) -	485,670	6.3
c. Known municipal STP's -		
Axtell	1,750	<0.1
Beattie	920	<0.1
Blue Rapids	9,065	0.1
Frankfort	3,525	<0.1
Greenleaf	1,650	<0.1
Hanover	2,850	<0.1
Marysville	13,450	0.2
Randolph	370	<0.1
Washington	9,780	0.1
Waterville	3,060	0.1
d. Septic tanks - Unknown	?	-
e. Industrial - Unknown	?	-
f. Direct precipitation* -	69,030	0.9
Total	7,726,510	100.0

2. Outputs -

Lake outlet - Big Blue River 4,192,595

3. Net annual N accumulation - 3,533,915 kg.

* See Working Paper No. 175.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Big Blue River	20	328
Otter Creek	13	182
West Fancy Creek	15	286
N. Fork Fancy Creek	15	249
Coon Creek	14	875
Little Blue River	66	251
Mobidoux Creek	29	402
Black Vermillion River	23	280
Clear Fork	11	204

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
McIntire Creek	0.075	0.548
Corndodger Creek	0.067	1.083
Cedar Creek	0.040	0.868

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	22.28	18.70	120.6	55.3

Vollenweider phosphorus loadings (g/m^2/yr) based on mean depth and 11-year median hydraulic retention time of Tuttle Creek Reservoir:

"Dangerous" (eutrophic loading)	0.86
"Permissible" (oligotrophic loading)	0.43

V. LITERATURE REVIEWED

Anonymous, 1975. Draft environmental statement: Operation and maintenance - Tuttle Creek Reservoir, Kansas. Kansas City Distr., Corp. of Engrs., Kansas City, MO.

Klaassen, Harold E., and G. Richard Marzolf, 1971. Relationships between distributions of benthic insects and bottom-feeding fishes in Tuttle Creek Reservoir. Reservoir Fisheries & Limnology, Special Publ. No. 8, Amer. Fish. Soc.

Kring, R. Lynn, 1977. Personal communication (revised reservoir morphometry; primary productivity). KS Dept. of Health & Environment, Topeka.

Marzolf, G. R., and John A. Osborne, 1972. Primary production in a Great Plains reservoir. Verh. Internat. Verein. Limnol. 18: 126-133

Osborne, John A., and G. Richard Marzolf, 1972. Effect of spectral composition on photosynthesis in turbid reservoirs. Water Resources Res. Inst., KS St. U., Manhattan.

Schwartz, Joseph M., and G. R. Marzolf, 1972. Sediment characteristics and distribution in Tuttle Creek Reservoir, Kansas. Trans. KS Acad. of Sci. 74(1).

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SUM- MEAN SEC	MEAN CHLORA	IS- MIN 30	MEDIAN SECCHI P
2601	COPAN BLUFF RESERVOIR	0.017	0.055	431.667	4.217	10.000	0.004
2602	COUNCIL GROVE	0.064	0.030	485.889	9.789	10.481	0.029
2603	ELK CITY	0.038	0.590	490.400	3.232	14.000	0.003
2604	FALL RIVER RESERVOIR	0.053	0.470	488.667	7.683	9.200	0.026
2605	JOHN REDMOND RESERVOIR	0.110	1.250	492.667	9.467	8.200	0.066
2606	KANOPOLIS RESERVOIR	0.056	0.040	487.000	16.833	10.200	0.011
2607	MARION RESERVOIR	0.052	0.430	483.667	12.400	9.000	0.030
2608	MELVERN RESERVOIR	0.034	0.265	499.111	38.489	14.400	0.007
2609	MILFORD RESERVOIR	0.079	0.710	466.333	19.803	12.000	0.036
2610	NORTON RESERVOIR	0.122	0.110	476.750	21.360	6.000	0.036
2611	PERRY RESERVOIR	0.055	0.970	478.571	5.634	13.429	0.017
2612	POMONA RESERVOIR	0.040	1.240	481.333	6.312	13.000	0.021
2613	TORONTO RESERVOIR	0.067	0.425	488.500	6.503	13.000	0.011
2614	TUTTLE CREEK RESERVOIR	0.102	0.970	478.667	11.270	13.600	0.067
2615	WILSON RESERVOIR	0.023	0.265	445.222	8.867	13.400	0.004

LAKES RANKED BY INDEX NO.

RANK	LAKE CODE	LAKE NAME	INDEX NO.
1	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]

PERCENT OF LAKES <QT> <EVAL> VALUES (NUMBER OF LAKES <QT> <EVAL> VALUES)

LAKE CODE	LAKE NAME	<EUTRO TOTAL P	<EUTRO CHLRA	SUB-<EUTRO SECC	<EUTRO CHLRA	15-<EUTRO TP	<EUTRO SECC CHLRA P	INDEX NO
2301	CEDAR BLUFF RESERVOIR	100 (144)	100 (144)	100 (144)	93 (134)	57 (82)	89 (128)	539
2302	COUNCIL GROVE	29 (42)	29 (42)	36 (52)	43 (62)	64 (92)	29 (42)	238
2303	ELK CITY	66 (125)	51 (73)	7 (10)	100 (144)	7 (10)	100 (144)	350
2304	FALL RIVER RESERVOIR	57 (82)	57 (82)	14 (20)	71 (102)	79 (113)	50 (72)	328
2305	JOHN REDMOND RESERVOIR	14 (20)	8 (10)	8 (10)	50 (72)	93 (134)	7 (10)	164
2306	KANOPOLIS RESERVOIR	43 (62)	43 (62)	29 (42)	21 (30)	72 (103)	64 (92)	274
2307	MARION RESERVOIR	64 (92)	64 (92)	43 (62)	29 (42)	86 (123)	72 (104)	357
2309	MELVERN RESERVOIR	79 (113)	82 (118)	86 (123)	0 (0)	0 (0)	79 (113)	326
2310	MILFORD RESERVOIR	21 (30)	36 (52)	79 (113)	14 (20)	50 (72)	14 (20)	214
2311	NORTON RESERVOIR	7 (10)	93 (133)	64 (92)	7 (10)	100 (144)	21 (30)	292
2312	PERRY RESERVOIR	50 (72)	14 (20)	57 (82)	86 (123)	25 (36)	43 (62)	276
2313	POMONA RESERVOIR	71 (103)	7 (10)	50 (72)	64 (92)	39 (56)	36 (52)	267
2314	TORONTO RESERVOIR	36 (52)	72 (103)	21 (30)	79 (113)	39 (56)	57 (82)	303
2315	TUTTLE CREEK RESERVOIR	8 (10)	18 (25)	71 (101)	36 (52)	14 (20)	8 (10)	136
2316	WILSON RESERVOIR	93 (133)	82 (118)	93 (133)	57 (82)	25 (36)	89 (128)	439

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

| | | |

[illegible]

APPENDIX D

PHYSICAL and CHEMICAL DATA

[illegible]

| | | |

APPENDIX I

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

[illegible]

[illegible]

[illegible]

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]
[illegible]
[illegible]

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

STORET RETRIEVAL DATE [illegible]

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO3+NO2 N-TOTAL MG/L	00625 TOT KJEL N TOTAL MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
[illegible]	[illegible]		0.240	3.200	0.855	0.815	0.135
[illegible]	[illegible]		0.304	1.500	0.845	0.815	0.110
[illegible]	[illegible]		0.440	0.507	0.828	0.485	
[illegible]	[illegible]		1.650	2.300	0.432	0.190	0.130
[illegible]	[illegible]		1.700	1.100	0.22[illegible]	2.072	0.110
[illegible]	[illegible]		0.960	1.400	0.75[illegible]	1.100	0.210
[illegible]	[illegible]		0.430	1.500	0.825	1.030	0.105
[illegible]	[illegible]		1.570	7.200	1.950	0.440	0.750
[illegible]	[illegible]		1.500	1.055	0.830	0.125	0.210
[illegible]	[illegible]		[illegible].340	0.650	0.815	0.820	0.110
[illegible]	[illegible]		0.330	0.500	0.200	0.040	0.130
[illegible]	[illegible]		0.230	1.700	0.825	0.820	0.130
[illegible]	[illegible]		1.150	0.400	0.850	0.105	0.210

[illegible]

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	TOT. KJEL.	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	[illegible]	N	TOTAL	[illegible]	[illegible]
			MG/L	MG/L	MG/L	MG/L P	MG/L P
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	14	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	14	35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	14	25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	15	00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	14	50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	15	05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	14	12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	12	27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	14	07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	14	58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	14	45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	13	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		[illegible]	N	TOTAL	[illegible]	
TO	DAY	FEET	MG/L	MG/L	MG/L	MG/L	MG/L
[illegible]	13	15	0.040	2.150	0.775	0.115	0.240
[illegible]	14	15	1.240	2.460	0.110	0.130	0.405
[illegible]	13	40	0.680	0.985	0.825	0.060	0.280
[illegible]	14	40	2.380	2.180	0.432	0.120	0.270
[illegible]	1>	30	1.640	2.080	0.38>	0.130	0.220
[illegible]	14	45	0.760	1.450	1.120	[illegible]	0.175
[illegible]	01	40	0.580	1.720	0.840	[illegible]	0.210
[illegible]	12	10	1.480	4.280	0.175	0.130	0.380
[illegible]	16	45	0.450	1.330	0.830	0.140	0.380
[illegible]	14	30	0.340	1.160	0.840	0.080	0.280
[illegible]	28	20	0.890	0.850	0.820	0.075	0.180
[illegible]	09	50	0.850	0.450	0.825	0.065	0.170
[illegible]	15	25	0.320	1.100	0.830	0.040	0.230

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							

[illegible]

[illegible]

[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							
[illegible]							

[illegible]

[illegible]

[illegible]

[illegible]										
[illegible]										
[illegible]										
[illegible]										

[illegible]

[illegible]

[redacted]

[redacted]										
[redacted]										
[redacted]										
[redacted]										

[illegible]

[illegible]
[illegible]
SEATTLE
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

[illegible]									
[illegible]									
[illegible]									
[illegible]									
[illegible]									
[illegible]									
[illegible]									
[illegible]									
[illegible]									
[illegible]									
[illegible]									
[illegible]									
[illegible]									

[illegible]

[redacted]

[illegible]

[illegible]

[illegible]										
[illegible]										
[illegible]										
[illegible]										